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A NOVEL SWITCHED RELUCTANCE MOTOR WITH WOUND-CORES PUT ON STATOR AND ROTOR POLES

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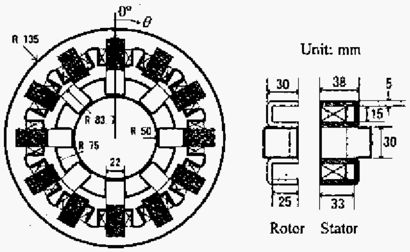
Introduction

A switched reluctance motor (SRM) has simple construction and high reliability. In recent years, the advancement of power electronics technology has made its performance higher. In this paper, we proposed a novel SRM with wound-cores made of the grain-oriented silicon steel. Since the grain-oriented silicon steel has high saturation flux density and less iron loss comparing with the non-oriented silicon steel, it is expected that the torque and efficiency are improved. We calculate characteristics of the novel SRM using the nonlinear dynamic analysis method proposed by authors [1].



(a) Novel SRM. (b) Cross section of poles.
Fig. 1 Structure of the novel SRM with wound-cores put on stator and rotor poles.

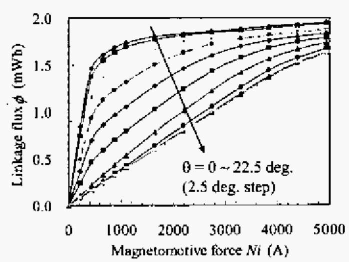


Fig. 2 Flux – MMF curves of the novel SRM calculated by FEA.

Calculation of Characteristics of a Novel Switched Reluctance Motor

Fig. 1 shows structure of the novel SRM used in the consideration. The SRM is three phase motor which has 12 stator poles and 8 rotor poles, respectively. The two wound-cores made of the grain-oriented silicon steel are put on each stator and rotor poles. In the figure, the rotor position θ is set to 0° when the rotor is in the align position. Fig. 2 shows flux-MMF curves of the SRM calculated by finite element analysis (FEA). The nonlinear magnetic circuit model of the SRM can be made by using the flux-MMF curves [1]. Fig. 3 shows the electromagnetic and motion coupled model for the SRM. The proposed model is consisted of "Motor drive circuit," "Magnetic circuit model," and "Motion calculation blocks." In the proposed model, when the rotor position θ is given, the controller generates transistor gate signal, and the phase current i is calculated. The MMF Ni is determined by the phase current. When the MMF is determined, the flux ϕ is obtained from the magnetic circuit model. The induced voltage e' is calculated by the linkage flux based on Faraday's low. The motor torque τ is obtained from magnetic energy W_{FM}. The rotational speed n is decided by the motion equation. An integral of the rotational speed gives the rotor position θ. All the above calculations are performed simultaneously on SPICE.

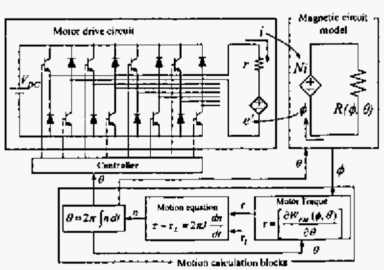
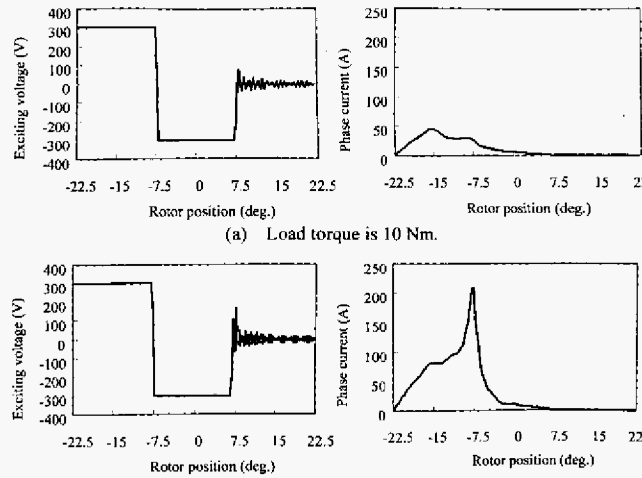


Fig. 3 Electromagnetic and motion coupled model for the novel SRM.

Fig. 4 shows calculated waveforms of an exciting voltage and a phase current when a load torque is 10 N·m and 40 N·m, respectively. Fig. 5 shows characteristics of the novel SRM, (a) is rotational speed, (b) is phase current, and (c) is output power. It is understood that the novel SRM has torque of 33 N·m and output power of 12 kW when a phase current is 42.8 A which is rated value.



(a) Load torque is 10 Nm.

(b) Load torque is 40 Nm.

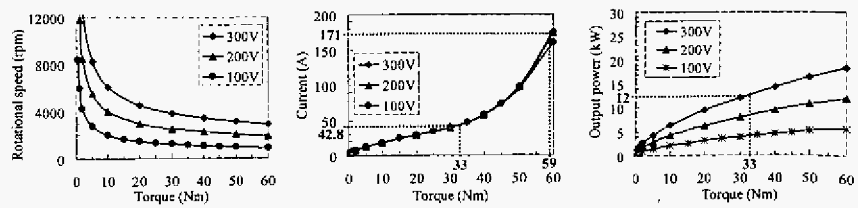
Fig. 4 Exciting voltage and phase current waveforms.
(Left: exciting voltage; Right: phase current.)

Conclusion

We proposed the novel switched reluctance motor with wound-cores put on stator and rotor poles, and calculated performance of the SRM using the nonlinear dynamic analysis method.

References

[1] T. Tsukii, K. Nakamura, O. Ichinokura, *Electrical Engineering in Japan*, **142**, 50 (2003).



(a) Rotational speed. (b) Phase current. (c) Output power.

Fig. 5 Characteristics of the novel SRM